IS31AP4990D

1.2W AUDIO POWER AMPLIFIER WITH ACTIVE-LOW SHUTDOWN MODE

March 2024

DESCRIPTION

The IS31AP4990D has been designed for demanding audio applications such as mobile phones and permits the reduction of the number of external components.

It is capable of delivering 1.2W of continuous RMS output power into an 8Ω load @ 5V.

An externally-controlled shutdown mode reduces the supply current to less than 1μA. It also includes internal thermal shutdown protection.

The unity-gain stable amplifier can be configured by external gain setting resistors.

FEATURES

- Operating from V_{CC} = 2.7V ~ 5.5V
- 1.2W output power @ V_{CC} = 5V, THD+N= 1%,
- f = 1kHz, with 8Ω load
- Ultra-low consumption in shutdown mode (1μA)
- Near-zero pop & click
- Ultra-low distortion
- Unity gain stable
- UTQFN-9 (1.5mm × 1.5mm) package
- RoHS & Halogen-Free Compliance
- TSCA Compliance

APPLICATIONS

- Mobile phones
- PDAs
- Portable electronic devices
- Notebook computer

TYPICAL APPLICATION CIRCUIT

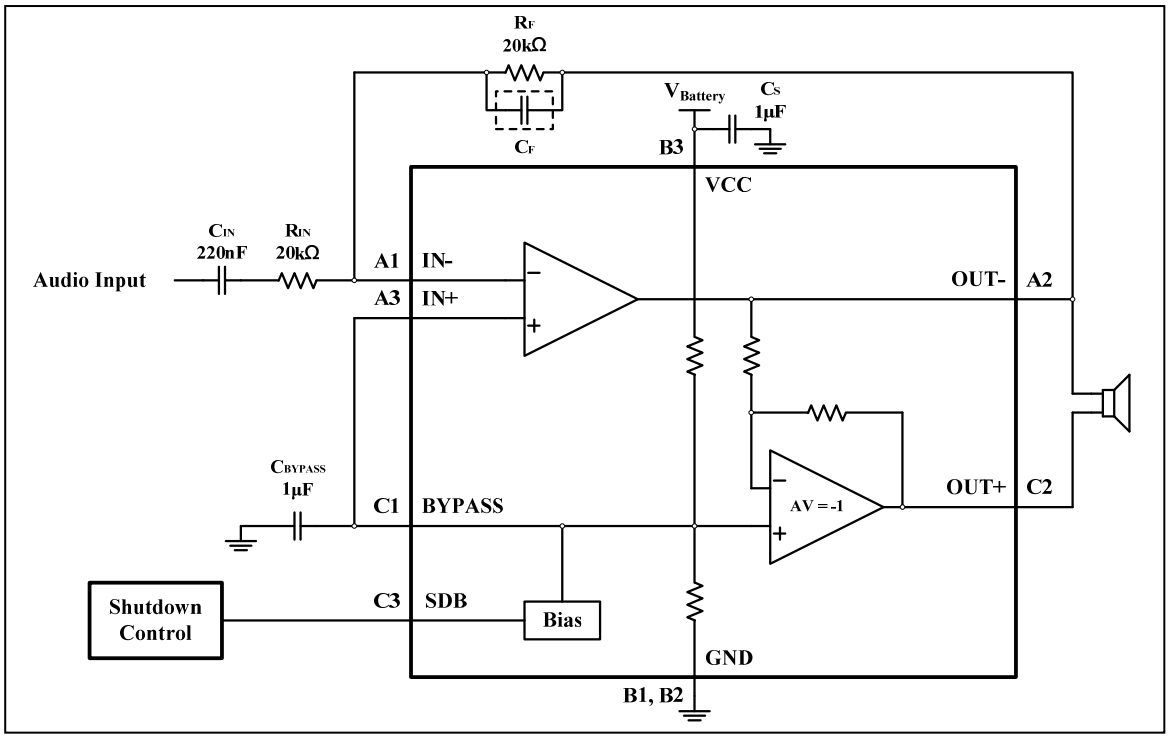


Figure 1 Typical Application Circuit (Single-ended Input)

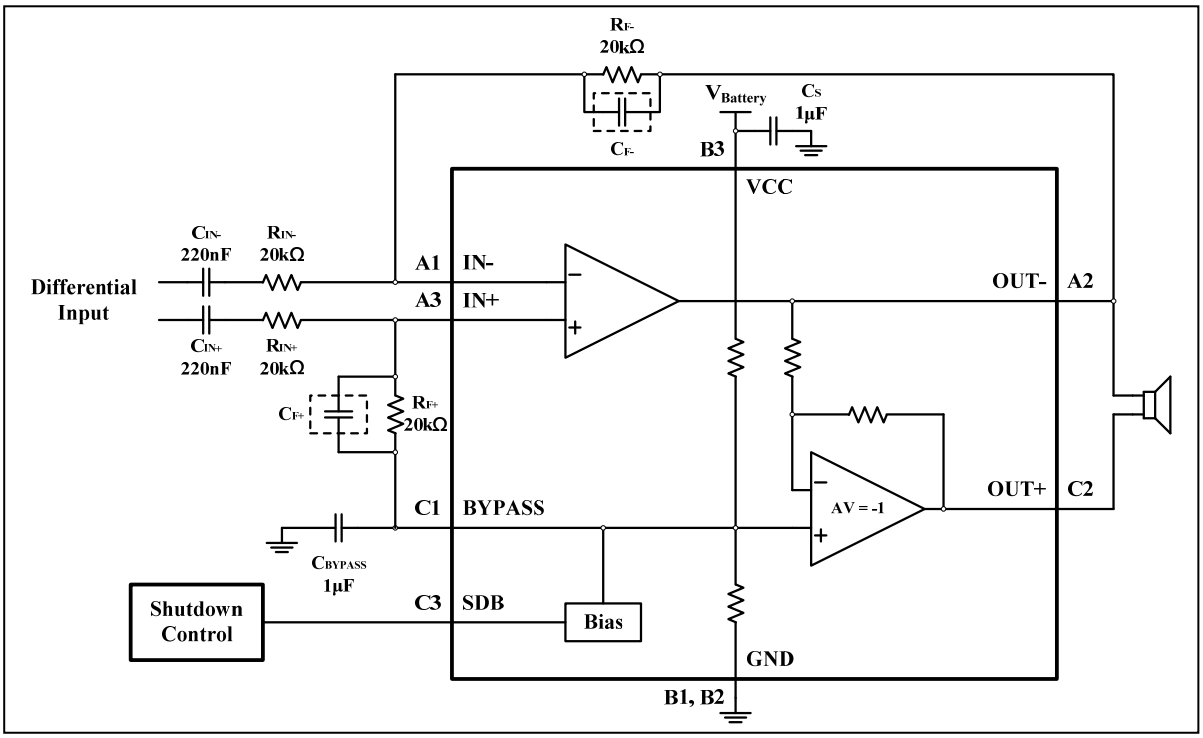
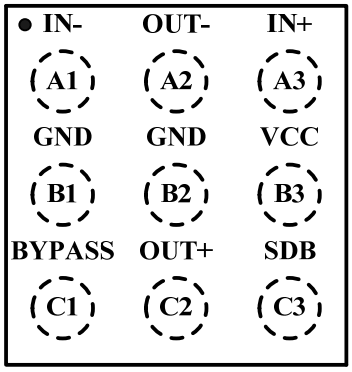


Figure 2 Typical Application Circuit (Differential Input)

PIN CONFIGURATION

Package	Pin Configuration (Top View)
UTQFN-9	

PIN DESCRIPTION

No.	Pin	Function Description
A1	IN-	Negative input of the first amplifier. Connected to the feedback resistor R_{F-} and to the input resistor R_{IN-}.
A2	OUT-	Negative output. Connected to the load and to the feedback resistor R_{F-}.
A3	IN+	Positive input of the first amplifier.
B1,B2	GND	Ground.
B3	VCC	Supply voltage.
C1	BYPASS	Bypass capacitor pin which provides the common mode voltage (V_{CC}/2).
C2	OUT+	Positive output. Connected to the load.
C3	SDB	The device enters in shutdown mode when a low level is applied on this pin.

ORDERING INFORMATION

Industrial Range: -40°C to +85°C

Order Part No.	Package	QTY/Reel
IS31AP4990D-UTLS2-TR	UTQFN-9, Lead-free	3000

ABSOLUTE MAXIMUM RATINGS

Supply voltage, V_{CC}	-0.3V ~ +6.0V
Voltage at any input pin	-0.3V ~ V_{CC}+0.3V
Maximum junction temperature, T_{JMAX}	+150°C
Storage temperature range, T_{STG}	-65°C ~ +150°C
Operating temperature range, T_A	-40°C ~ +85°C
ESD (HBM) ESD (CDM)	±7kV ±500V

Note: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

T_A = -40°C ~ +85°C, V_{CC} = 2.7V ~ 5.5V, unless otherwise noted. Typical value are T_A = +25°C.

Symbol	Parameter	Condition		Min.	Typ.	Max.	Unit
V_{CC}	Power supply			2.7		5.5	V
I_{CC}	Quiescent current	V_{CC} = 5V, V_{IN} = 0V, I_O = 0A, no load			3.8	6.4	mA
		V_{CC} = 3V, V_{IN} = 0V, I_O = 0A, no load			2.8	5.1	
I_{SD}	Shutdown current	V_{SDB} = GND, no load				1	μA
V_{IH}	Shutdown voltage input high			1.4			V
V_{IL}	Shutdown voltage input low					0.4	V
V_{OS}	Output offset voltage					25	mV
Po	Output power (8Ω)	V_{CC} = 5V	THD+N = 1%, f = 1kHz		1.20		W
			THD+N = 10%, f = 1kHz		1.50		
		V_{CC} = 3V	THD+N = 1%, f = 1kHz		0.418		
			THD+N = 10%, f = 1kHz		0.525		
t_{WU}	Wake-up time (Note 1)	V_{CC} = 5V, C_{BYPASS} = 1μF			115		ms
		V_{CC} = 3V, C_{BYPASS} = 1μF			102		
THD+N	Total harmonic distortion + noise (Note 1)	V_{CC} = 5V, P_O = 0.5Wrms, f = 1kHz			0.23		%
		V_{CC} = 3V, Po = 0.3Wrms, f = 1kHz			0.15		
PSRR	Power supply rejection ratio (Note 1)	V_{CC} = 5V, $V_{Ripple\ p\text{-}p}$ = 200mV, Input grounded	f = 217Hz		61		dB
			f = 1kHz		65		
		V_{CC} = 3.6V, 4.2V, $V_{Ripple\ p\text{-}p}$ = 200mV Input grounded	f = 217Hz		62		
			f = 1kHz		66		

Note 1: Guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTIC

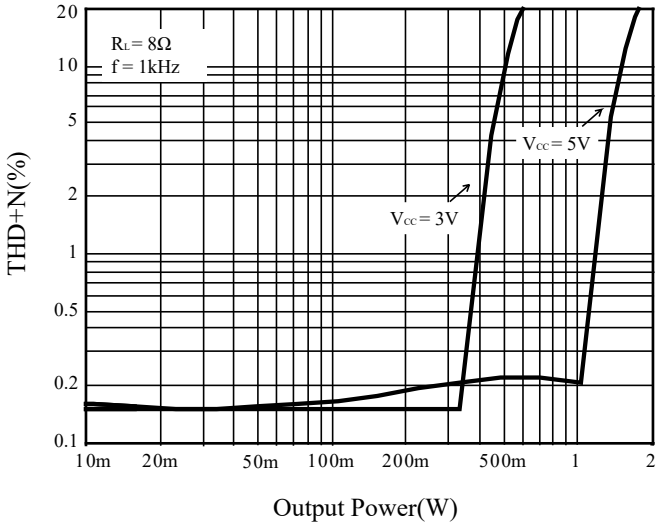


Figure 3 THD+N vs. Output Power

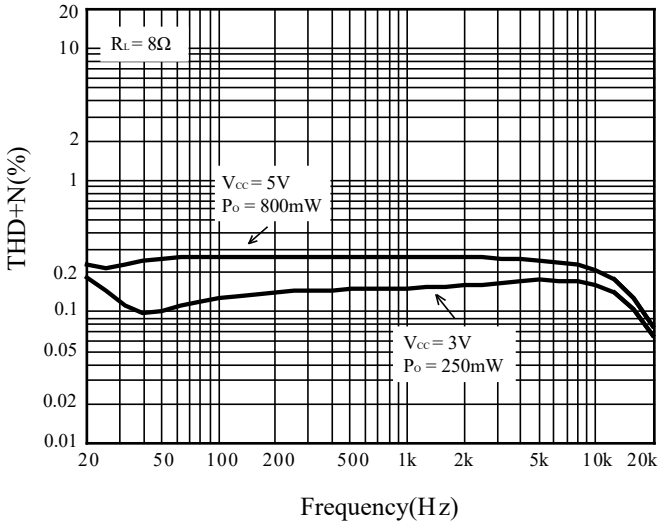


Figure 4 THD+N vs. Frequency

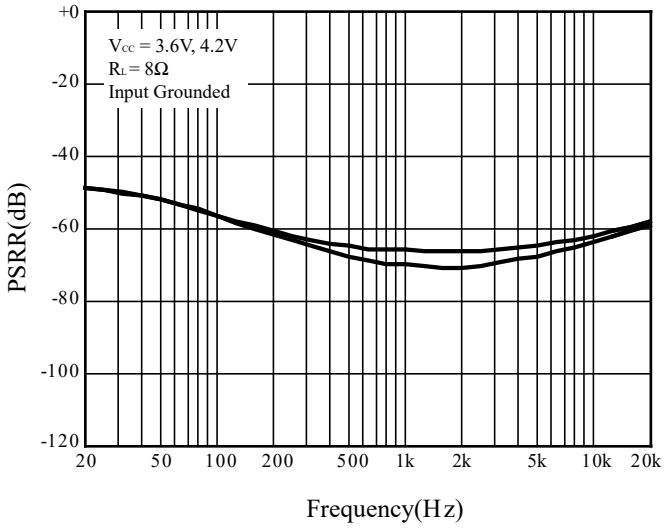


Figure 5 PSRR vs. Frequency

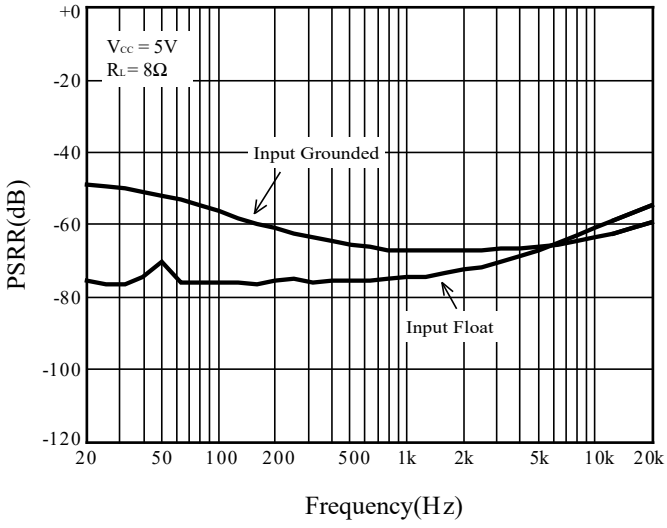


Figure 6 PSRR vs. Frequency

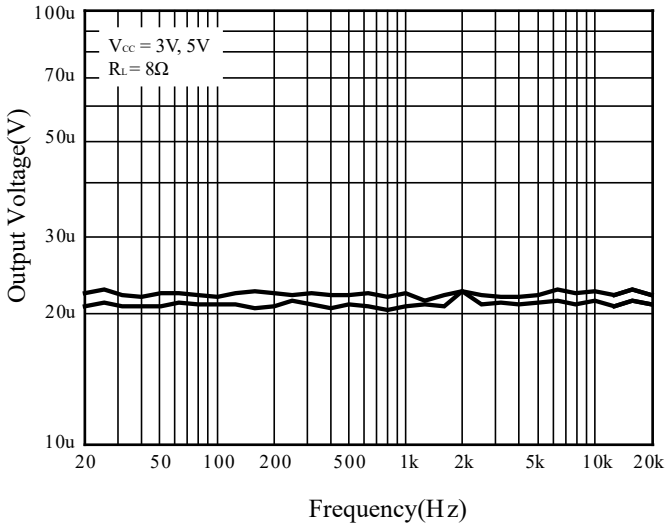


Figure 7 Noise Floor

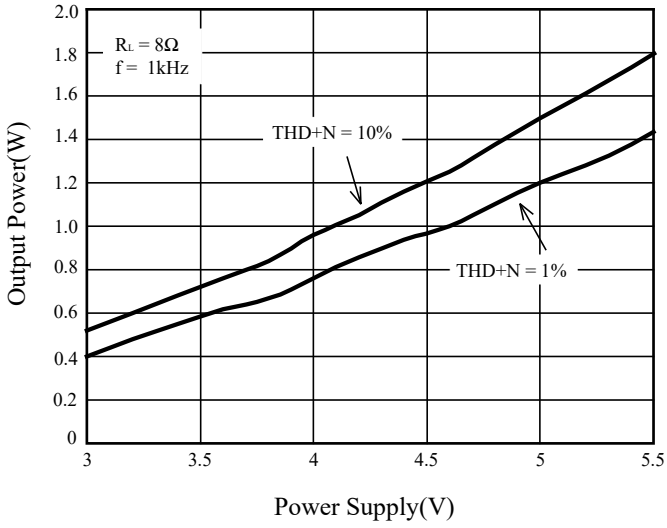


Figure 8 Output Power vs. Power Supply

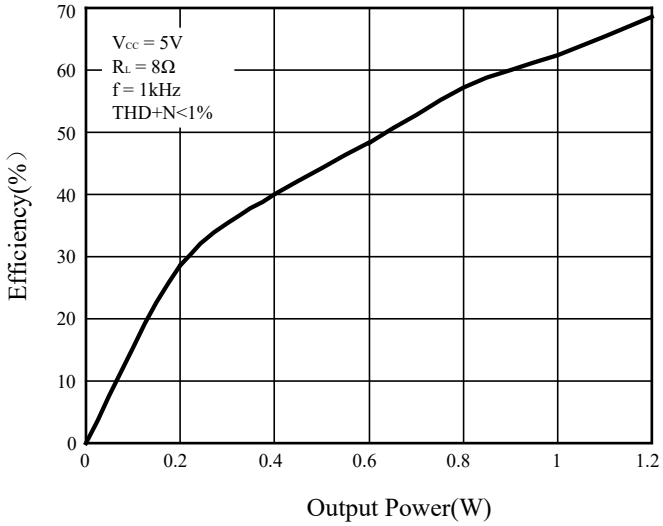


Figure 9 Efficiency vs. Output Power

APPLICATION INFORMATION

BTL CONFIGURATION PRINCIPLE

The IS31AP4990D is a monolithic power amplifier with a BTL output type. BTL (bridge tied load) means that each end of the load is connected to two single-ended output amplifiers. Thus, we have:

Single-ended output 1 = V_{OUT+} = V_{OUT} (V)

Single ended output 2 = V_{OUT-} = -V_{OUT} (V)

and V_{OUT+} - V_{OUT-} = 2V_{OUT} (V)

The output power is:

$$P_{OUT} = \frac{(2V_{OUT\ RMS})^2}{R_L}$$

For the same power supply voltage, the output power in BTL configuration is four times higher than the output power in single ended configuration.

GAIN IN A TYPICAL APPLICATION SCHEMATIC

The typical application schematic is shown in Figure 1 on page 1.

In the flat region (no C_{IN} effect), the output voltage of the first stage is (in Volts):

$$V_{OUT-} = (-V_{IN})\frac{R_F}{R_{IN}}$$

For the second stage: V_{OUT+} = -V_{OUT-} (V)

The differential output voltage is (in Volts):

$$V_{OUT+} - V_{OUT-} = 2V_{IN}\frac{R_F}{R_{IN}}$$

The differential gain, G_v, in shourt, is given by:

$$G_v = \frac{V_{OUT+} - V_{OUT-}}{V_{IN}} = 2\frac{R_F}{R_{IN}}$$

V_{OUT+} is in phase with V_{IN} and V_{OUT-} is phased 180° with V_{IN}. This means that the positive terminal of the loudspeaker should be connected to V_{OUT+} and the negative to V_{OUT-}.

LOW AND HIGH FREQUENCY RESPONSE

In the low frequency region, C_{IN} starts to have an effect. C_{IN} forms with R_{IN} a high-pass filter with a -3dB cut-off frequency. f_{CL} is in Hz.

$$f_{CL} = \frac{1}{2\pi R_{IN} C_{IN}}$$

In the high frequency region, you can limit the bandwidth by adding a capacitor (C_F) in parallel with R_F. It forms a low-pass filter with a -3dB cut-off frequency. f_{CH} is in Hz.

$$f_{CH} = \frac{1}{2\pi R_F C_F}$$

DECOUPLING OF THE CIRCUIT

Two capacitors are needed to correctly bypass the IS31AP4990D: a power supply bypass capacitor C_S and a bias voltage bypass capacitor C_{BYPASS}.

C_S has particular influence on the THD+N in the high frequency region (above 7kHz) and an indirect influence on power supply disturbances. With a value for C_S of 1µF, you can expect THD+N levels similar to those shown in the datasheet.

In the high frequency region, if C_S is lower than 1µF, it increases THD+N and disturbances on the power supply rail are less filtered.

On the other hand, if C_S is higher than 1µF, those disturbances on the power supply rail are more filtered.

C_{BYPASS} has an influence on THD+N at lower frequencies, but its function is critical to the final result of PSRR (with input grounded and in the lower frequency region).

If C_{BYPASS} is lower than 1µF, THD+N increases at lower frequencies and PSRR worsens.

If C_{BYPASS} is higher than 1µF, the benefit on THD+N at lower frequencies is small, but the benefit to PSRR is substantial.

Note that C_{IN} has a non-negligible effect on PSRR at lower frequencies. The lower the value of C_{IN}, the higher the PSRR is.

WAKE-UP TIME (t_{WU})

When the SDB pin is released to put the device ON, the bypass capacitor C_{BYPASS} will not be charged immediately. As C_{BYPASS} is directly linked to the bias of the amplifier, the bias will not work properly until the C_{BYPASS} voltage is correct. The time to reach this voltage is called wake-up time or t_{WU} and specified in the electrical characteristics table with C_{BYPASS} = 1µF.

POP PERFORMANCE

Pop performance is intimately linked with the size of the input capacitor C_{IN} and the bias voltage bypass capacitor C_{BYPASS}.

The size of C_{IN} is dependent on the lower cut-off frequency and PSRR values requested. The size of C_{BYPASS} is dependent on THD+N and PSRR values requested at lower frequencies.

Moreover, C_{BYPASS} determines the speed with which the amplifier turns ON.

CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

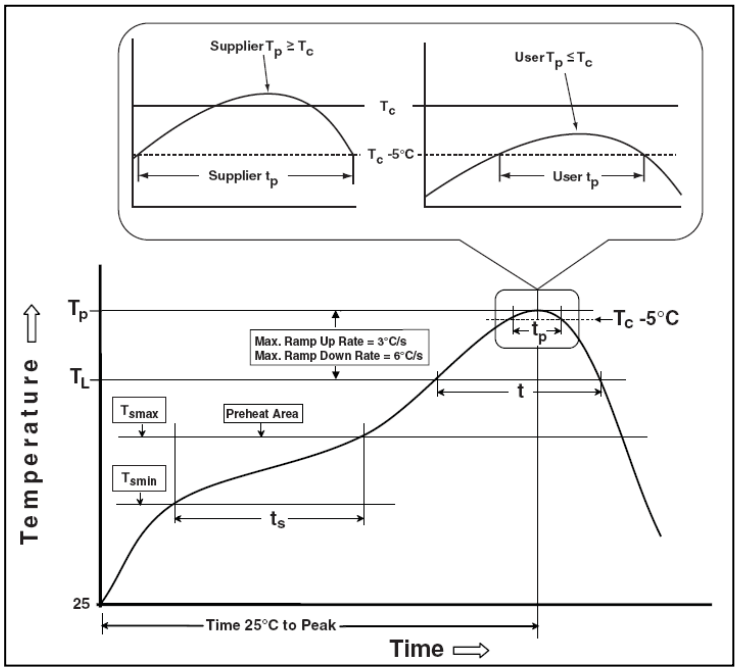
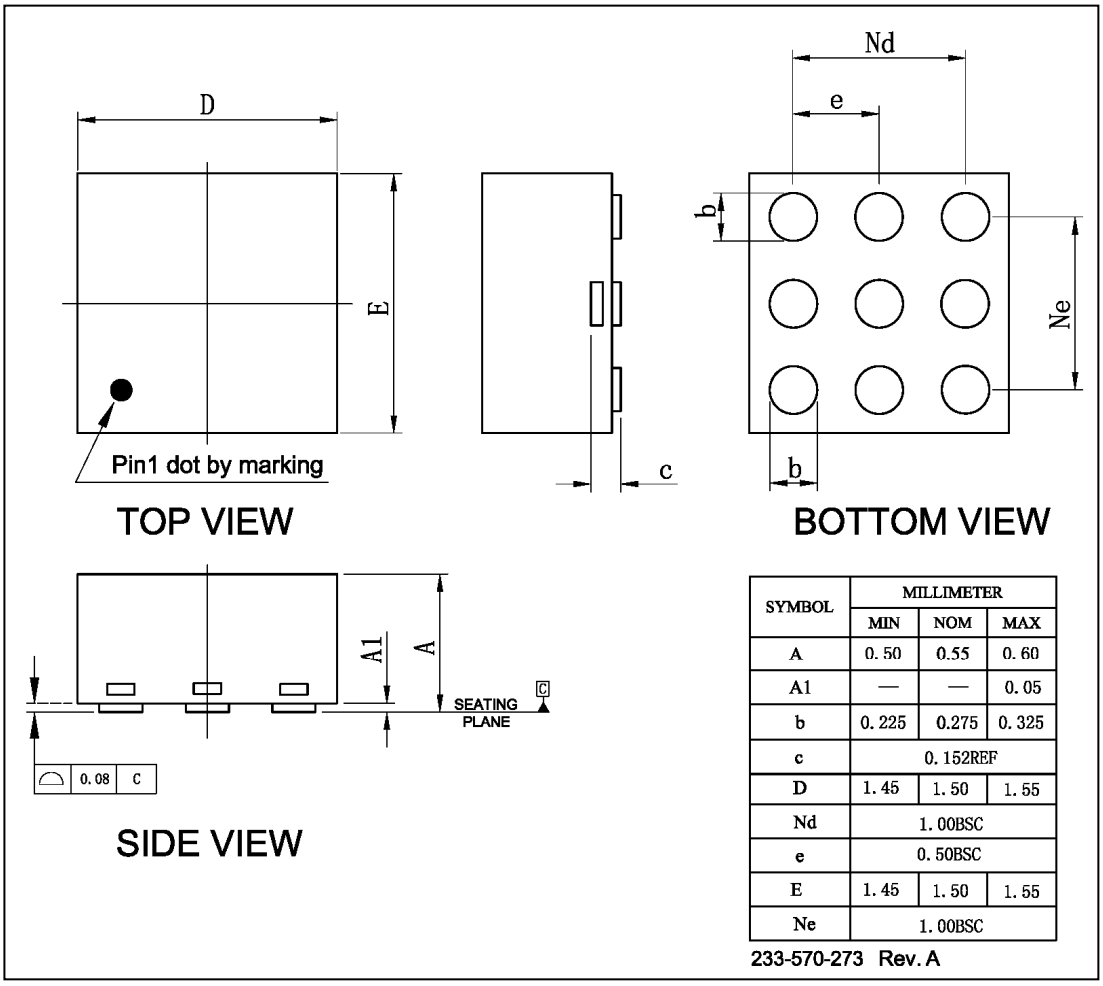


Figure 10 Classification Profile

PACKAGING INFORMATION

UTQFN-9

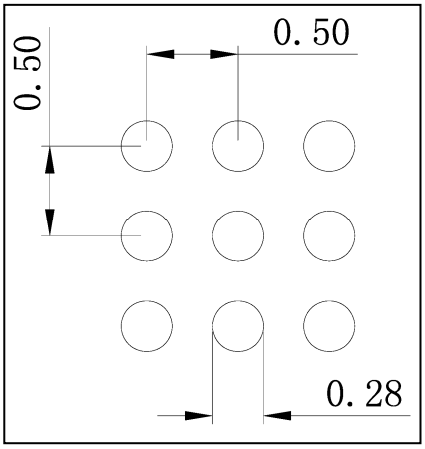


SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	—	—	0.05
b	0.225	0.275	0.325
c	0.152REF		
D	1.45	1.50	1.55
Nd	1.00BSC		
e	0.50BSC		
E	1.45	1.50	1.55
Ne	1.00BSC		

233-570-273 Rev. A

RECOMMENDED LAND PATTERN

UTQFN-9



Note:

1. Land pattern complies to IPC-7351.
2. All dimensions in MM.
3. This document (including dimensions, notes & specs) is a recommendation based on typical circuit board manufacturing parameters. Since land pattern design depends on many factors unknown (eg. User's board manufacturing specs), user must determine suitability for use.

REVISION HISTORY

Revision	Detail Information	Date
A	Initial release	2011.12.13
B	1. P.2 Add differential input circuit 2. P.10 Delete tape and reel information	2012.10.23
C	1. Add ESD value 2. Add C_{F-} for Figure 2	2014.06.24
D	1.Update to new Lumissil logo 2.Update POD and add LP, RoHS	2024.03.15